

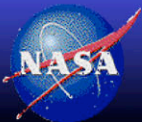
Terra SRBAVG Ed2D: Release Validation Summary

D. Doelling, D. Keyes, M. Nordeen
AS&M

D. Young
NASA Langley Research Center

C. Nguyen, R. Raju, J. Boghosian
SAIC

Fourth CERES-II Science Team Meeting
Williamsburg, VA, May 2-4, 2006



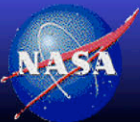
NASA Langley Research Center / Atmospheric Sciences



CERES Temporal Interpolation and Spatial Averaging (TISA)

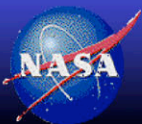
Goals

- Produce climate quality monthly means
 - Must maintain CERES instrument calibration
- Eliminate temporal sampling errors
- Retain consistency among TOA fluxes, cloud properties and surface fluxes



SRBAVG is the CERES gridded monthly product

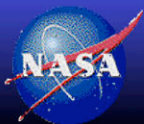
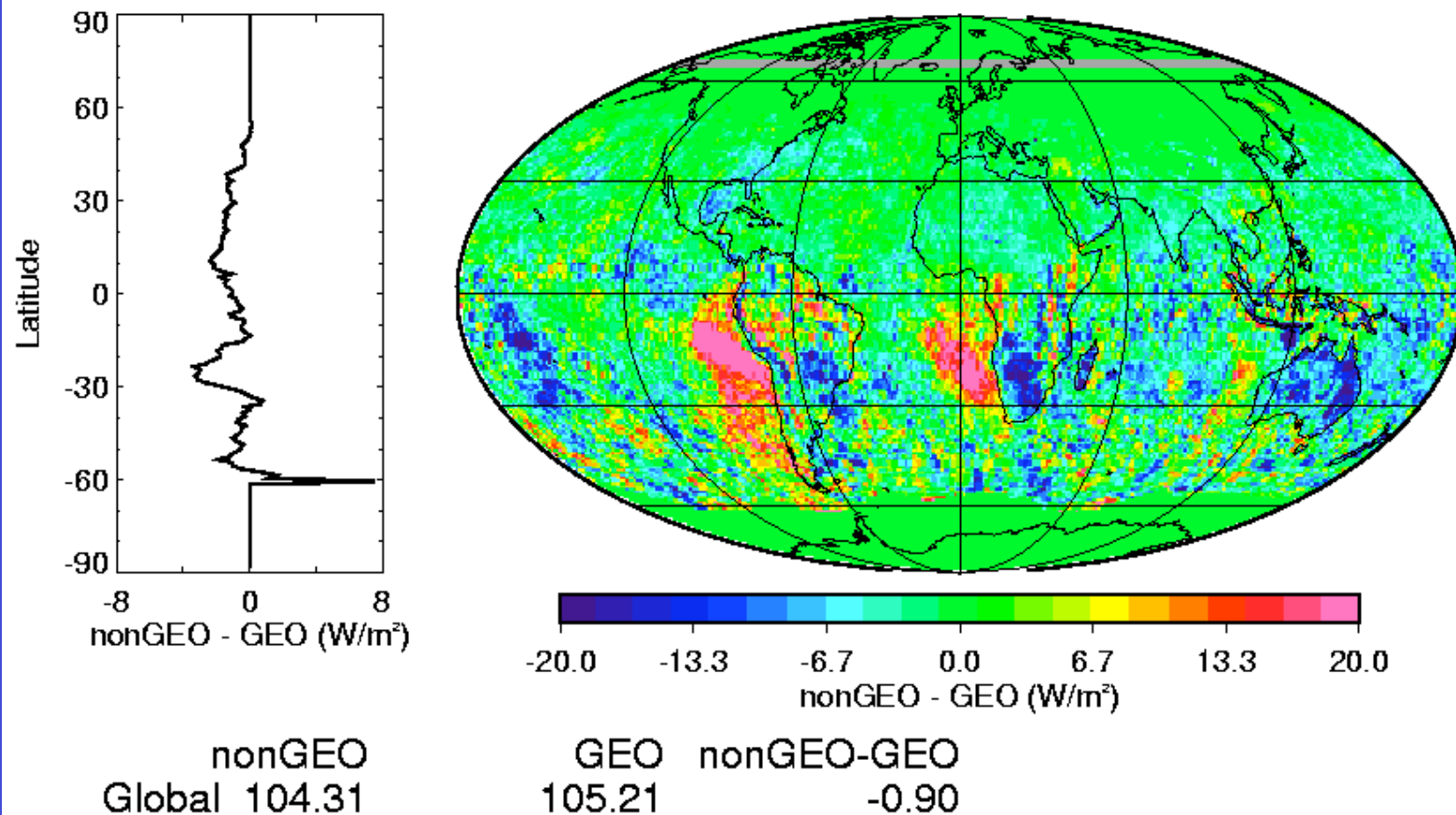
- **SRBAVG product status**
 - March 2000 to Feb 2003 Edition2D released
 - March 2003 to May 2004 GEO Beta6 soon to be released
 - Both Terra and Aqua SRBAVGs released there after
 - June 2004 to October 2005 GEO before the next STM
- **Validation results demonstrate robustness of interpolation**
 - Continued updates on the validation
- **Product details**
 - 1.0° grid
 - TOA, surface fluxes, and cloud properties
 - Product contains both the GEO and nonGEO monthly means
 - nonGEO: uses CERES fluxes
 - GEO: uses CERES and derived 3-hourly GEO fluxes to remove temporal sampling effects



SRBAVG results

Dec 2002 nonGEO - GEO SW

Terra 200212 Total-sky TOA SW Flux



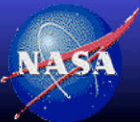
NASA Langley Research Center / Atmospheric Sciences



CERES 4-year TOA fluxes

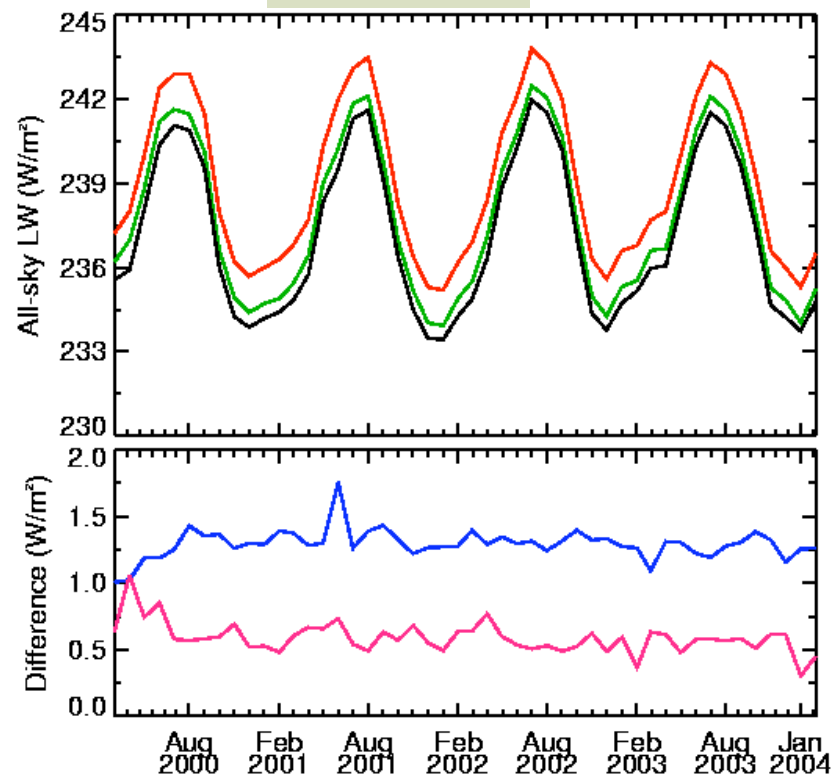
W_{m-2}	CERES ES-4 ERBE-like		CERES SRBAVG non-GEO		CERES SRBAVG GEO	
	3-year	4-year	3-year	4-year	3-year	4-year
OLR_{ALL-SKY}	239.0	239.0	237.7	237.7	237.1	237.2
SW_{ALL-SKY}	98.5	98.3	96.7	96.6	97.8	97.7
NET_{ALL-SKY}	3.8	3.9	6.9	7.0	6.4	6.5
OLR_{CLEAR-SKY}	266.7	266.7	266.3	266.4	264.0	264.1
SW_{CLEAR-SKY}	49.3	49.3	51.2	51.2	51.1	51.1
NET_{CLEAR-SKY}	25.4	25.3	23.8	23.8	26.3	26.2

- No surprises between the 3 and 4-year annual means



Terra ALL-SKY LW

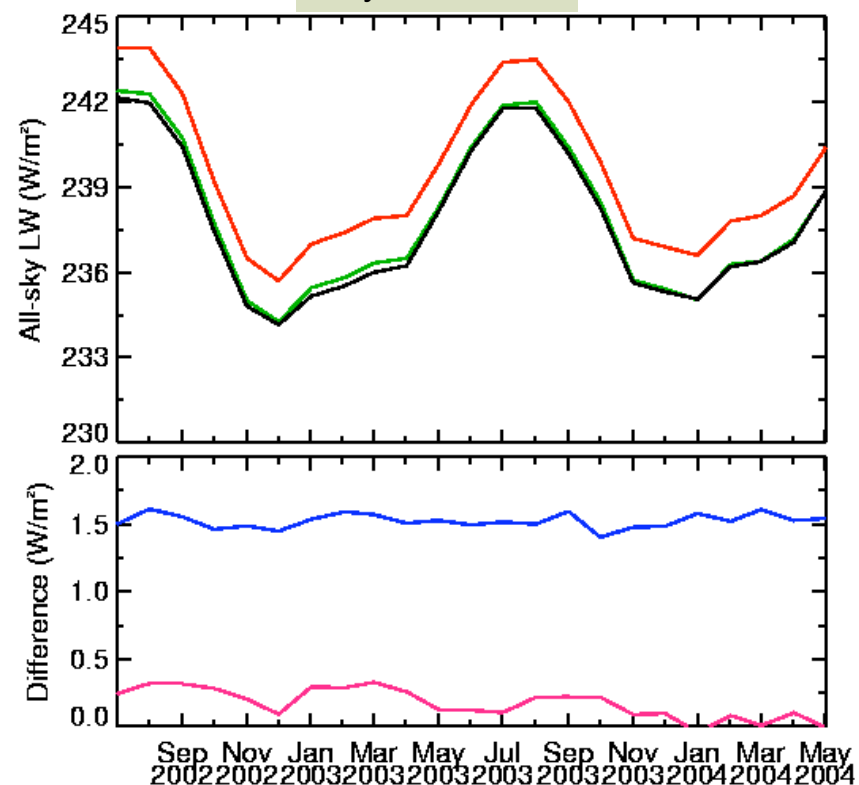
Mar00-Feb04



ALL-SKY LW		Avg	Difference		Avg
ERBElke	—	239.0	ERBElke-nonGEO	—	1.3
nonGEO	—	237.7	nonGEO-GEO	—	0.6
GEO	—	237.2			

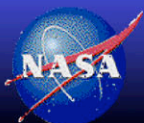
AQUA ALL-SKY LW

July02-June03



ALL-SKY LW		Avg	Difference		Avg
ERBElke	—	239.5	ERBElke-nonGEO	—	1.5
nonGEO	—	237.9	nonGEO-GEO	—	0.2
GEO	—	237.8			

- Aqua means are not annual

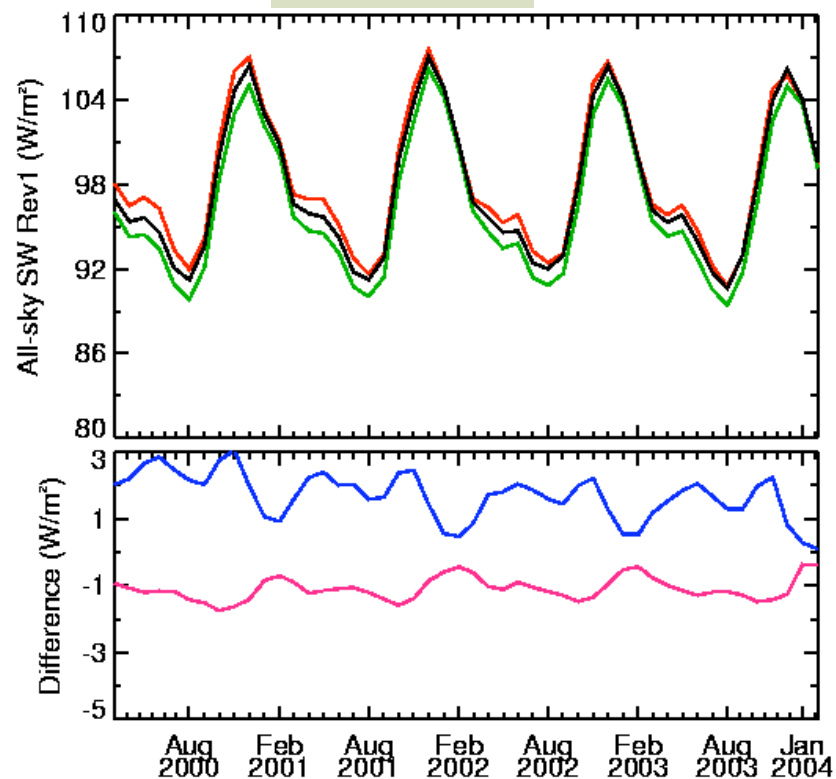


NASA Langley Research Center / Atmospheric Sciences



Terra ALL-SKY SW Rev1

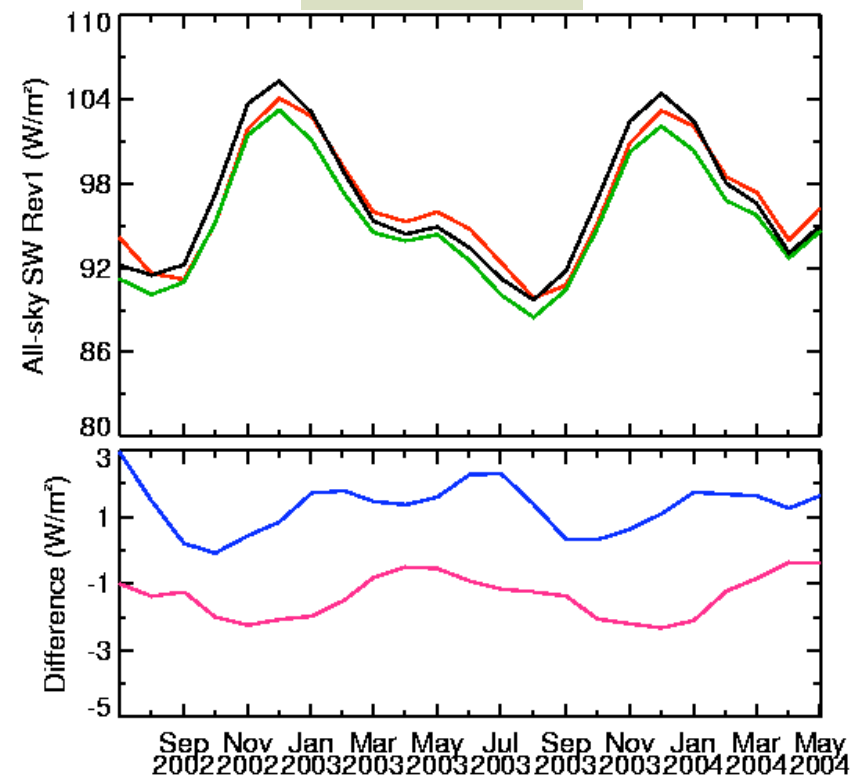
Mar00-Feb04



ALL-SKY SW Rev1 Avg		Difference		Avg
ERBElke	98.3	ERBElke-nonGEO	1.7	
nonGEO	96.6	nonGEO-GEO	-1.1	
GEO	97.7			

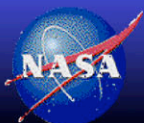
AQUA ALL-SKY SW Rev1

July02-June03



ALL-SKY SW Rev1 Avg		Difference		Avg
ERBElke	96.6	ERBElke-nonGEO	1.3	
nonGEO	95.3	nonGEO-GEO	-1.4	
GEO	96.7			

- ERBElke trend in the de-seasonalized and 30°N to 30°S fluxes



NASA Langley Research Center / Atmospheric Sciences

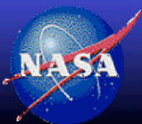


4-Year Multi-Dataset TOA Flux Comparison

Observed

PROJECT	CLOUDS	PROFILE	FLUXES
CERES-ERBELike			measured
CERES-nonGEO	<i>MODIS</i>		measured
CERES-GEO	<i>MODIS+GEO</i>	<i>GEOS</i>	measured
CERES-SARB	MODIS+GEO	GEOS	Fu-Liou
SRB	ISCCP obs	GEOS	Fu-Liou
ISCCP-FD	ISCCP obs	TOVS	
GEOS-4	Modeled	GEOS	Chou
NCEP-reanalysis	Modeled	NCEP	
ECMWF-ERA40	Modeled		

Modeled



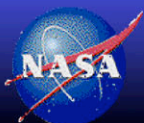
NASA Langley Research Center / Atmospheric Sciences



TOA global 4-year flux means (Mar00-Feb04)

Wm-2	CERES ES-4 ERBE-like	CERES SRBAVG non-GEO	CERES SRBAVG GEO	SRB GEWEX	ISCCP FD	NCEP REANAL- YSIS	ECMWF* ERA40
OLR _{ALL-SKY}	239.0	237.7	237.2	240.5	235.6	238.5	244.3
SW _{ALL-SKY}	98.3	96.6	97.7	101.3	105.5	117.3	107.0
NET _{ALL-SKY}	3.9	7.0	6.5	-2.1	1.4	-11.6	-8.3
OLR _{CLEAR-SKY}	266.7	266.4	264.1	268.0	262.0	270.3	264.9
SW _{CLEAR-SKY}	49.3	51.2	51.1	53.8	54.6	54.8	49.8
NET _{CLEAR-SKY}	25.3	23.8	26.2	18.0	25.9	19.1	28.2
OLR _{CLOUD-FORCING}	27.6	28.6	26.9	27.4	26.4	31.7	20.7
SW _{CLOUD-FORCING}	-49.0	-45.4	-46.6	-47.5	-50.9	-62.5	-57.2
NET _{CLOUD-FORCING}	-21.4	-16.8	-19.7	-20.0	-24.5	-30.7	-36.5

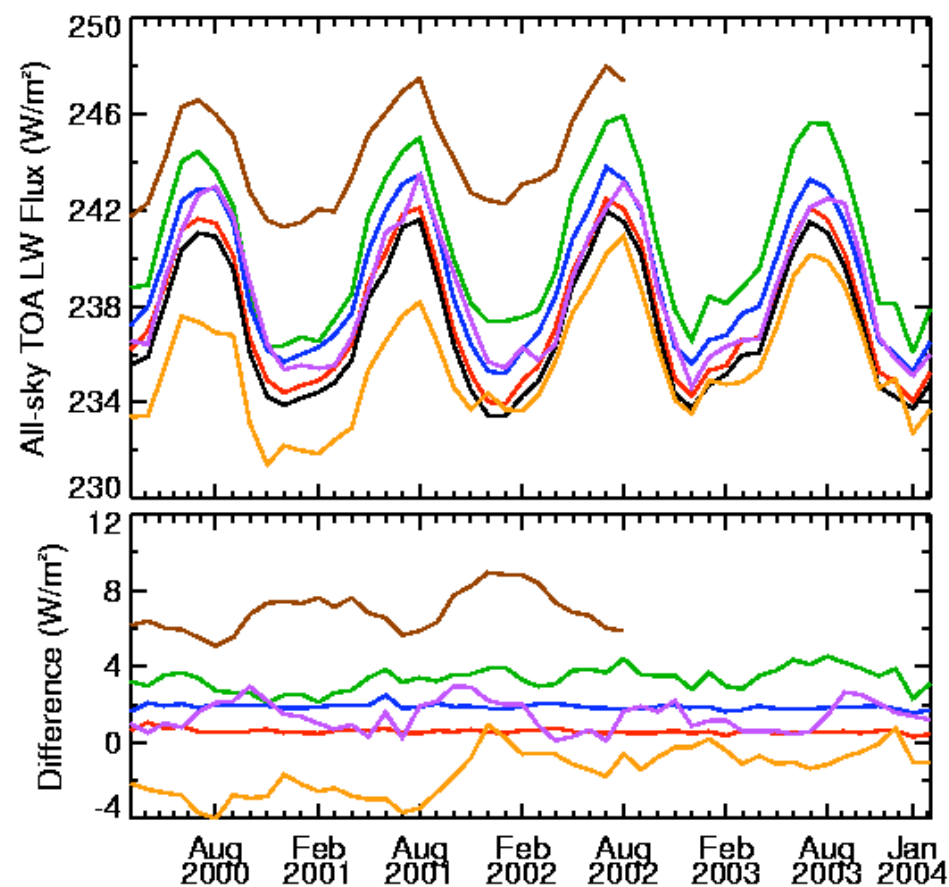
*ECMWF is from Mar00-Aug02



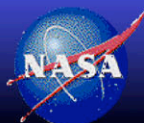
NASA Langley Research Center / Atmospheric Sciences



All-sky TOA LW



All-sky TOA LW		Difference		Avg
nonGEO	237.7	nonGEO - GEO	0.6	
GEO	237.2			
SRB	240.5	SRB - GEO	3.3	
ERBE_like	239.0	ERBE_like - GEO	1.9	
NCEP	238.5	NCEP - GEO	1.4	
ECMWF	244.3	ECMWF - GEO	6.9	
ISCCP FD	235.6	ISCCP FD - GEO	-1.5	

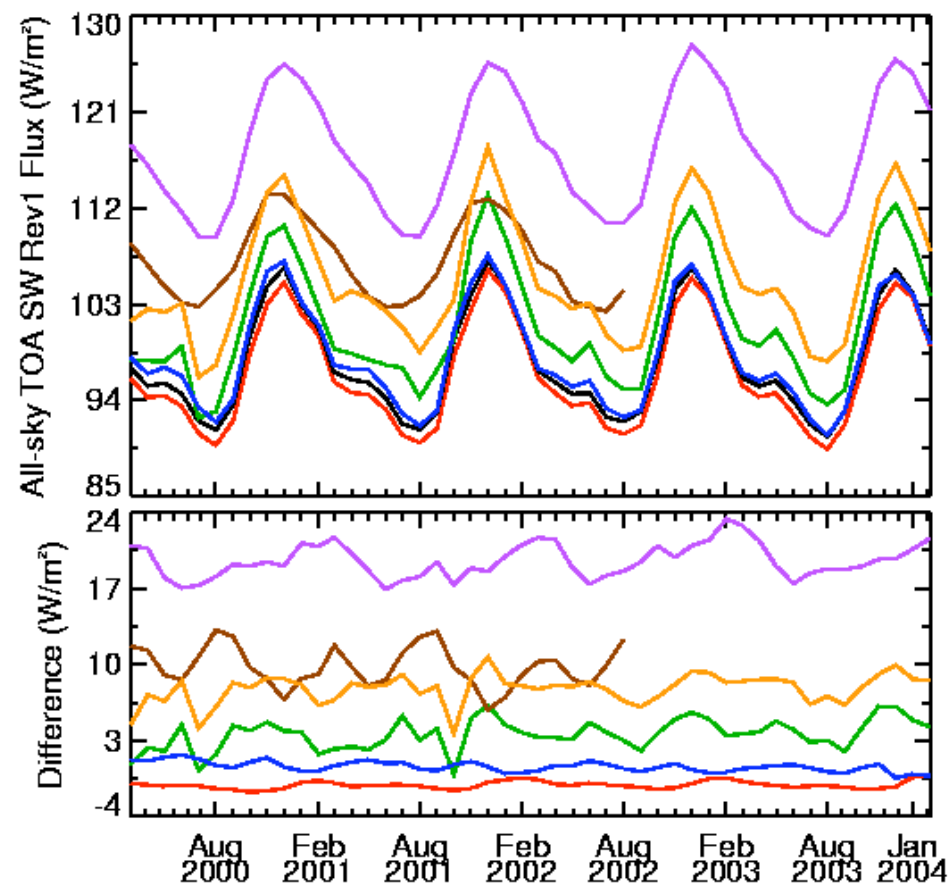


N

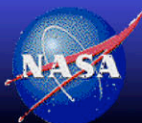


S

All-sky TOA SW Rev1



All-sky TOA SW Rev1		Difference		Avg
nonGEO	96.6	nonGEO - GEO	-1.1	
GEO	97.7			
SRB	101.3	SRB - GEO	3.6	
ERBE_like	98.3	ERBE_like - GEO	0.6	
NCEP	117.3	NCEP - GEO	19.6	
ECMWF	107.0	ECMWF - GEO	9.8	
ISCCP FD	105.5	ISCCP FD - GEO	7.8	



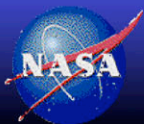
N



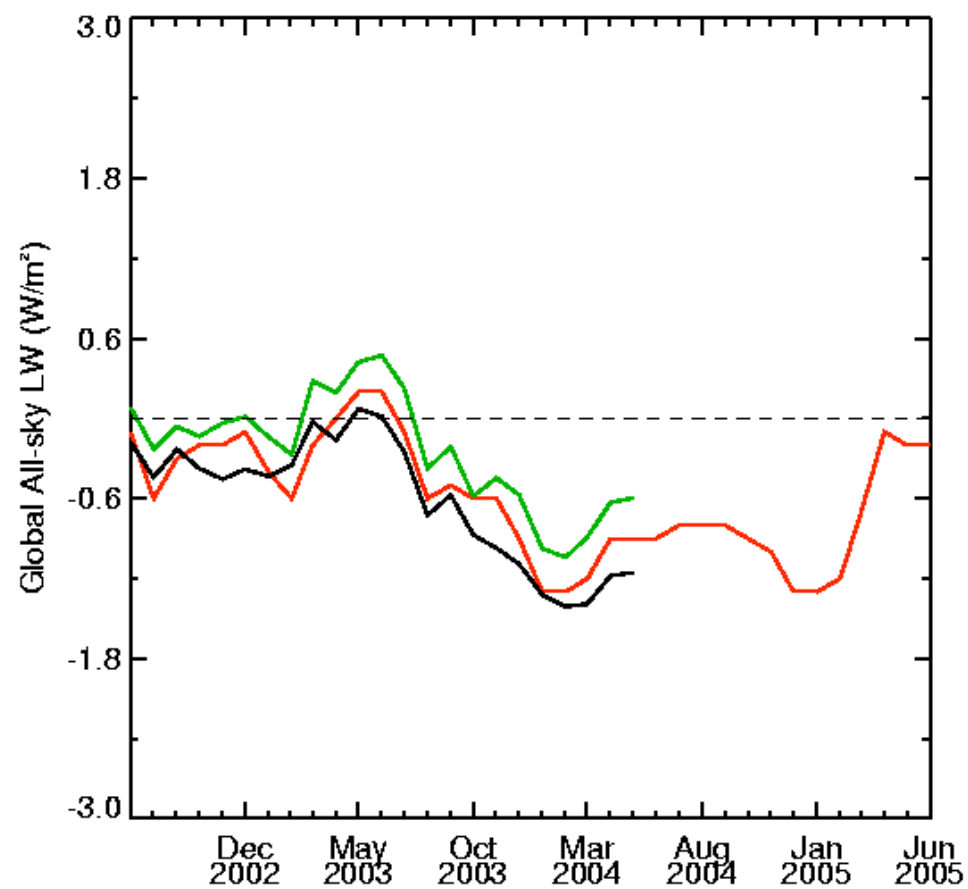
S

SRBAVG Validation

- Aqua Terra Comparisons - 2 year comparisons
 - Tests the instantaneous interpolation accuracy
- GEO calibration sensitivity study (VIS $\pm 5\%$, IR $\pm 5\%$)
 - Test effectiveness of GEO-CERES normalization
- 1 vs 3 hourly GEO derived fluxes
 - Tests for temporal sampling sensitivity
- Comparison of GEO surface fluxes with Surface flux measurements
 - Surface network provides an independent high temporal resolution data set
- Comparison of GEO BB fluxes with SARB - Given by Fred Rose
 - Consistency between cloud properties and fluxes
- Principal component (EOF) analysis of flux fields
 - Test for potential GEO viewing artifacts
- GEO derived directional models
 - Tests the NB-BB consistency with SZA
- GERB will ultimately provide the best independent high-resolution data set for testing the interpolation of GEO data

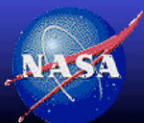


Global ALL-SKY LW BIAS Terra - Aqua (FM1 vs FM4)

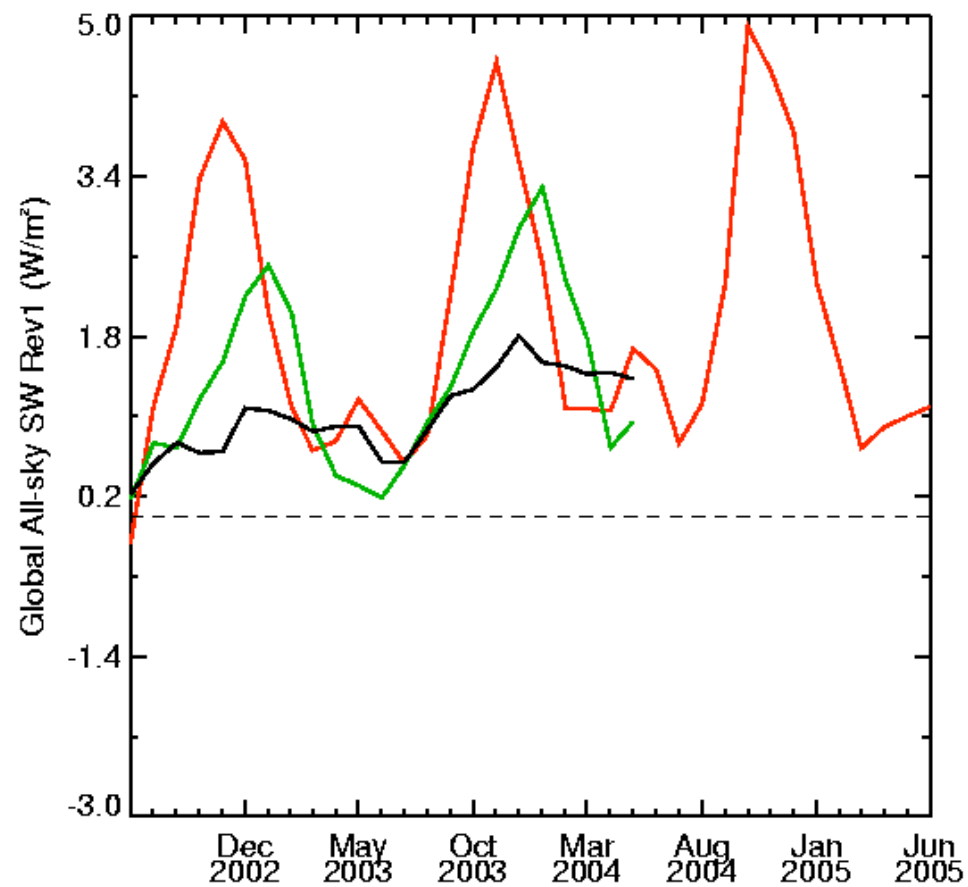


ALL-SKY LW BIAS		Avg	RMS
ERBElke	—	-0.6	0.7
nonGEO	—	-0.2	0.5
GEO	—	-0.6	0.8

- Terra - Aqua TOA LW global mean
- Aqua FM4 LW has trend, resolved in Ed3

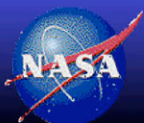


Global ALL-SKY SW Rev1 BIAS Terra - Aqua (FM1 vs FM4)

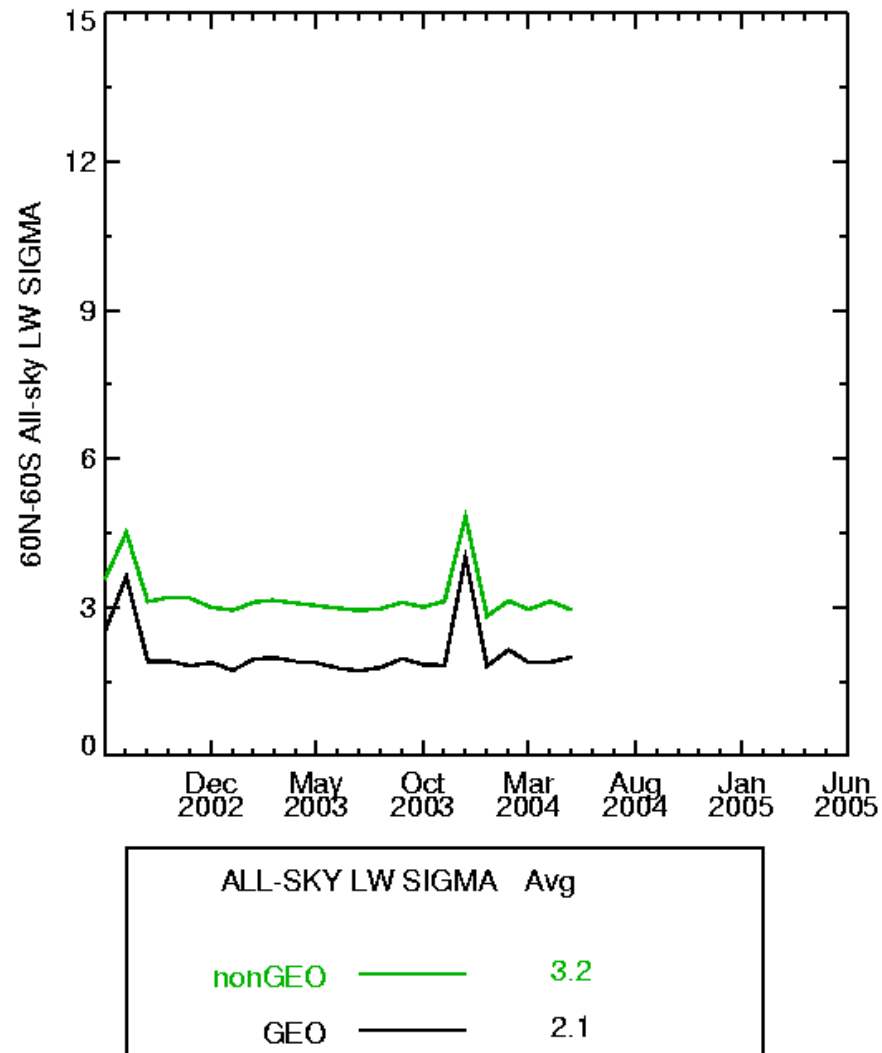


ALL-SKY SW Rev1 BIAS		Avg	RMS
ERBElike	—	1.9	2.3
nonGEO	—	1.4	1.6
GEO	—	1.0	1.1

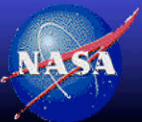
- Aqua FM4 SW has trend, resolved in Ed3



60N-60S ALL-SKY LW SIGMA
Terra - Aqua



- Sigma from all 1° regions from 60°N to 60°S
- Expect GEO sigma < nonGEO
- GEO fluxes improve temporal sampling

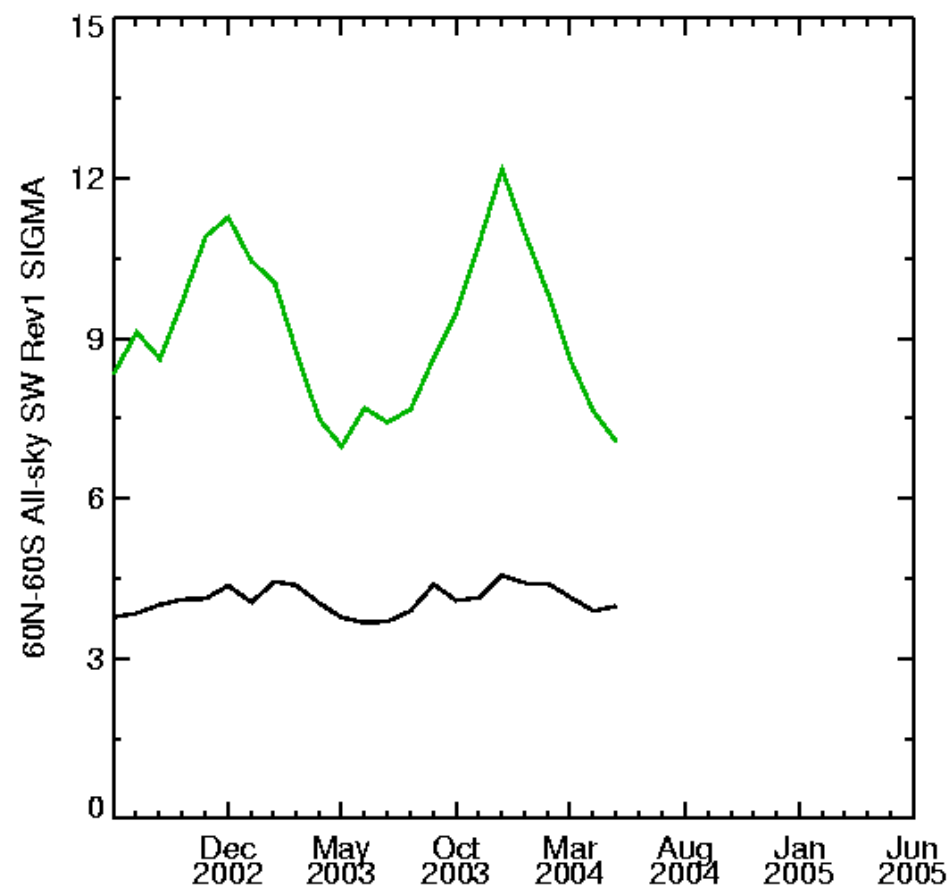


NA

Sciences

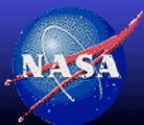


60N-60S ALL-SKY SW Rev1 SIGMA Terra - Aqua



ALL-SKY SW Rev1 SIGMA Avg

nonGEO	—	9.1
GEO	—	4.1



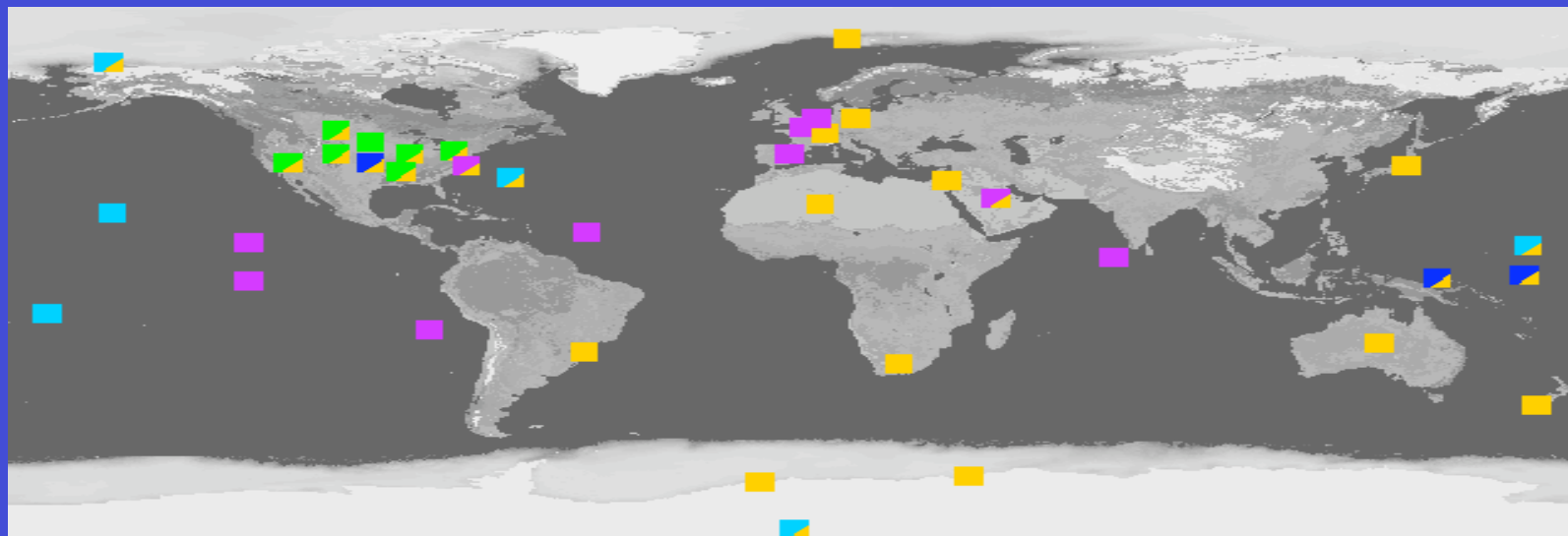
N



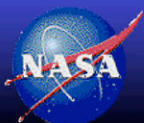
S

Surface Flux Comparisons

- Compare station surface LW and SW fluxes with SRBAVG monthly Model B (all-sky) LPSA/LPLA (Gupta model) fluxes

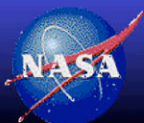


- Monthly site surface fluxes from CAVE
 - ARM, SURFRAD, CMDL, and BSRN quality controlled surface radiometer networks
 - 3 years of monthly fluxes per station (Mar00 to Feb03)
 - 36 stations across the globe

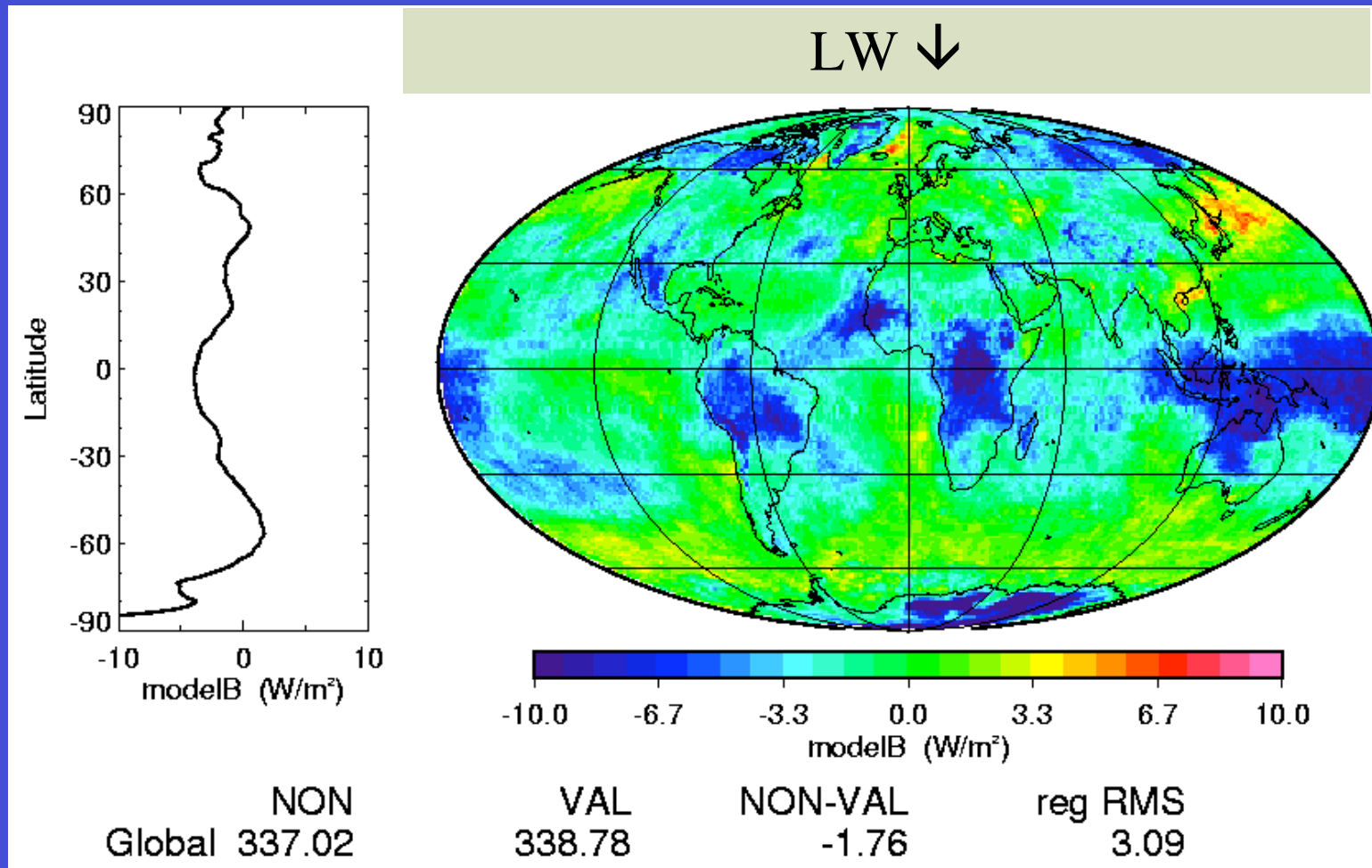


Surface Flux Comparisons

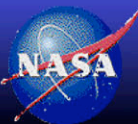
- **LPLA Longwave fluxes**
 - Surface longwave fluxes are independent from TOA
 - GEOS atmospheric state vertical profiles
 - GEO (low) cloud base heights
- **LPSA shortwave fluxes**
 - SW TOA major component
 - Cloud Amount
 - Cloud optical depth
- **Error (shown in Nov05 STM) discovered in surface flux computation**
 - SRBAVG uses same algorithm as SOFA
 - The bottom two layers and top two layers are combined
 - Only if both bottom layers existed did the lower layer get computed
 - Error was fixed - remarkable improvement



Error - Corrected SFC all-sky LW flux, Feb. 2002



- A combination of using all hourboxes and proper cloud bases

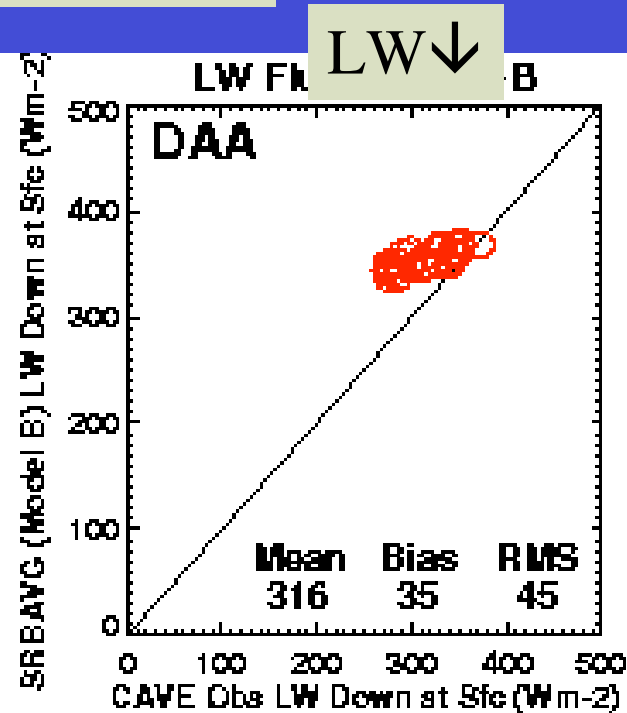
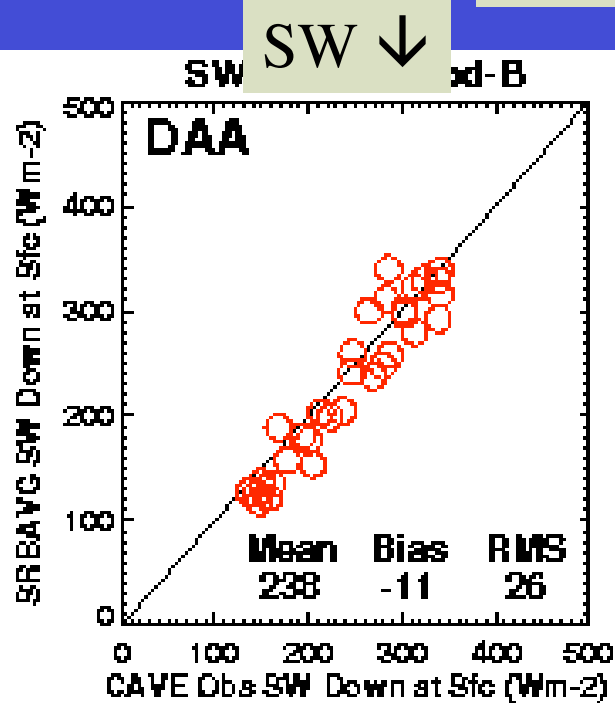


NASA Langley Research Center / Atmospheric Sciences

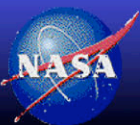
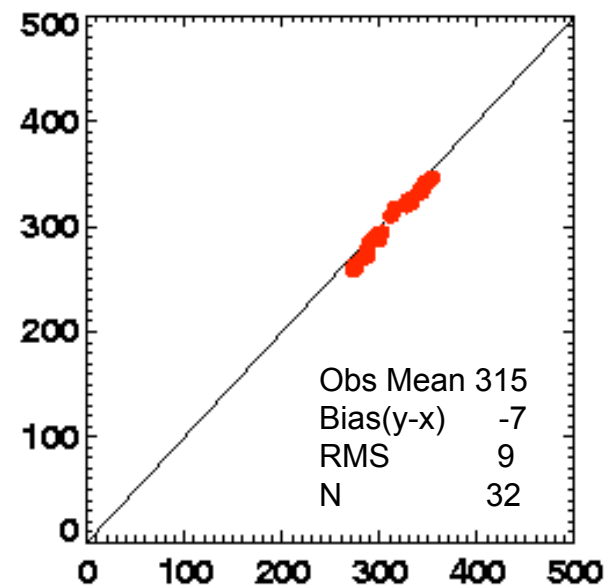
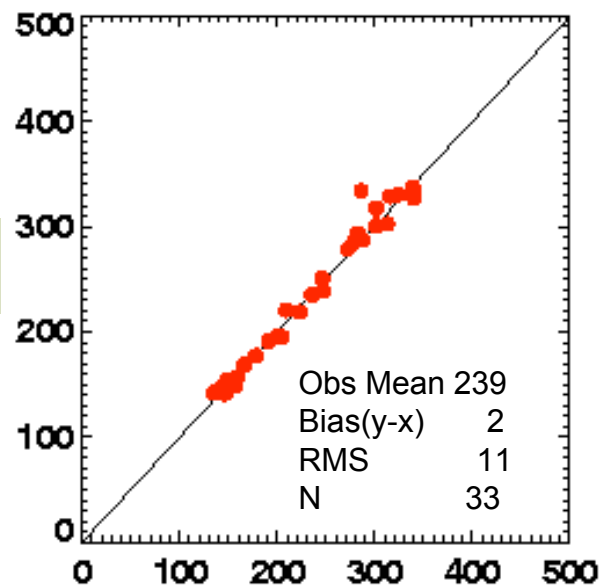


Daar South Africa

Error

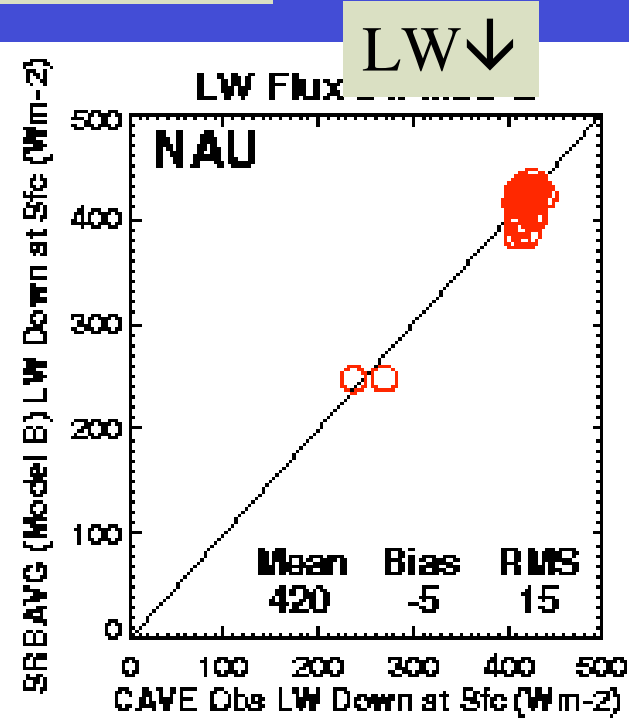
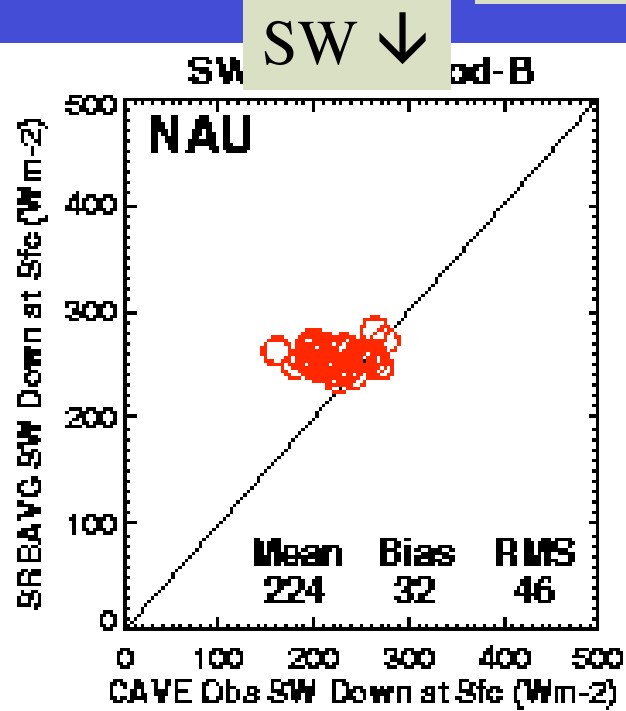


Corrected

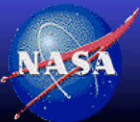
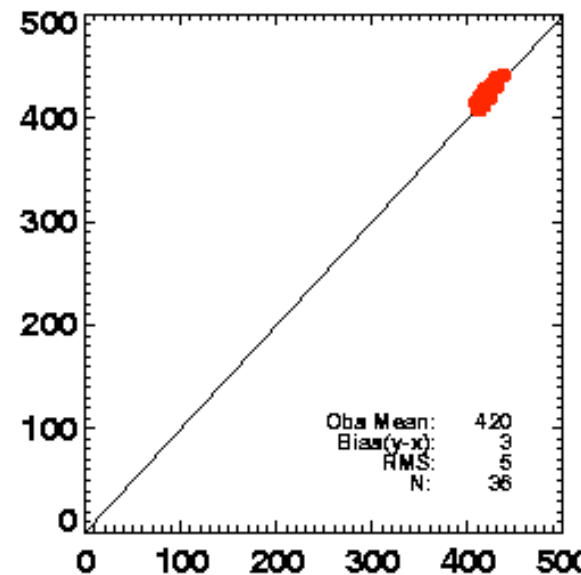
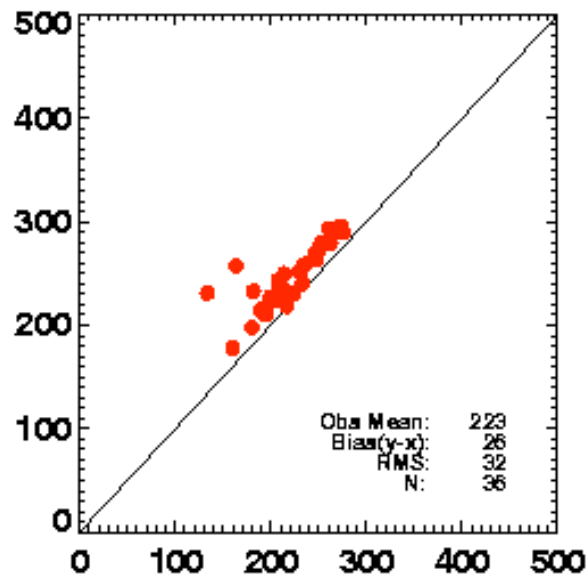


Nauru

Error

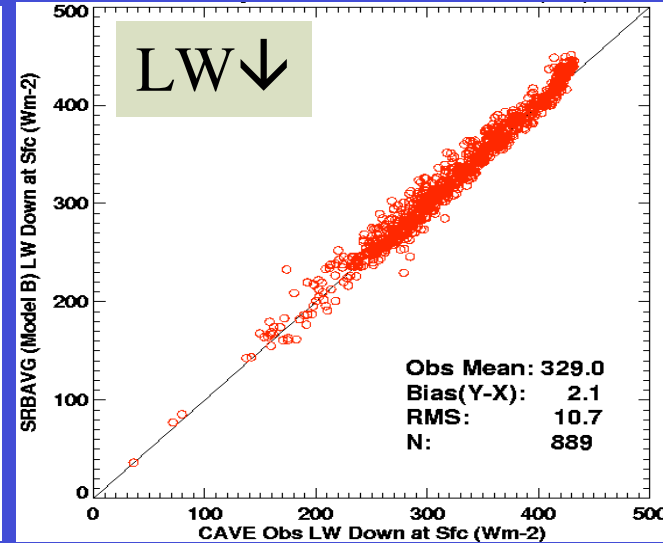
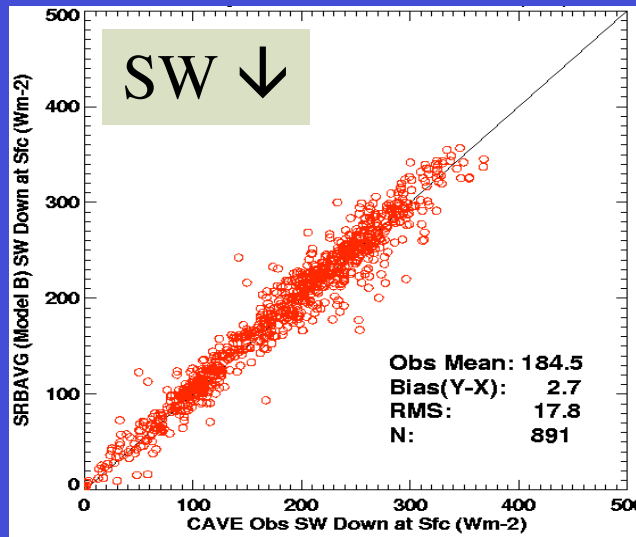


Corrected

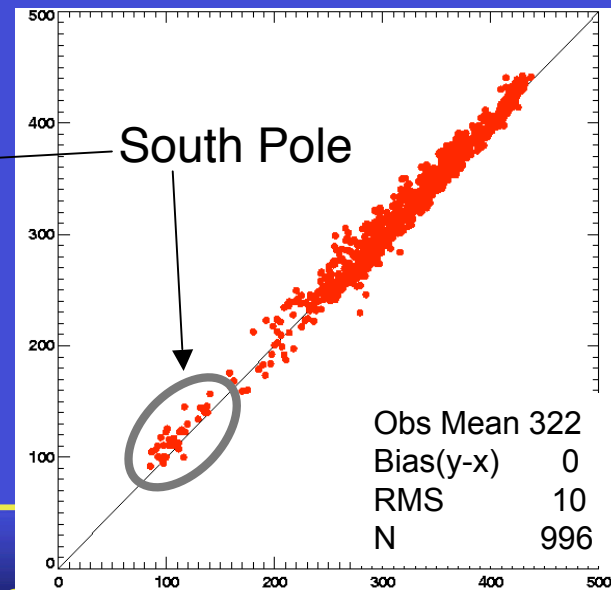
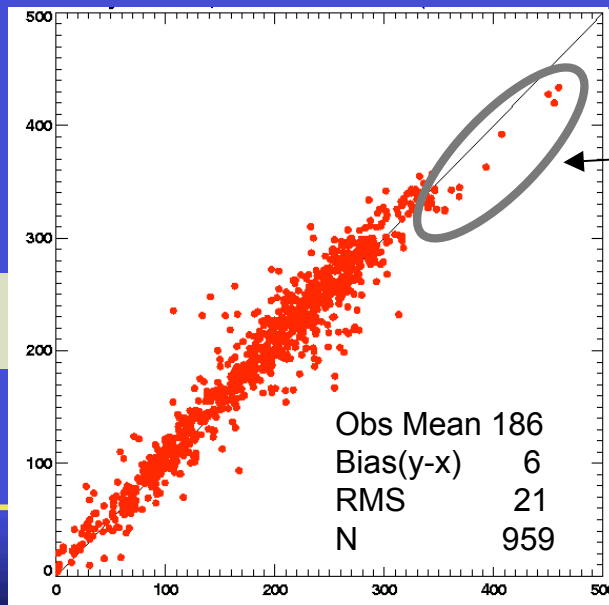


Comparison of site ground and SRBAVG monthly surface fluxes Mar00 - Feb03

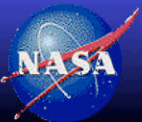
Error



Corrected



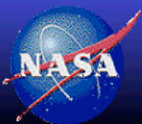
Syowa Antarctica, GVN Norway are excluded



Summary of Surface Flux Comparison

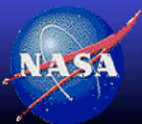
- The monthly SRBAVG surface (Model B) regional and ground fluxes are within the bias and RMS errors derived from instantaneous CERES footprint Model B (SOFA) and ground fluxes
 - 34 station result
 - SW bias is now consistent SOFA - *error* had smaller SW bias
 - SOFA SW cloudy sky overestimates, clear-sky underestimates
- Some surface stations (a point) may not representative of the 1° region, (coastal, terrain, etc.)

(%)	SW		LW	
	SOFA	SRBAVG	SOFA	SRBAVG
Bias	3.3	3.2	-0.6	0.0
RMS	15.0	11.3	7.4	3.1



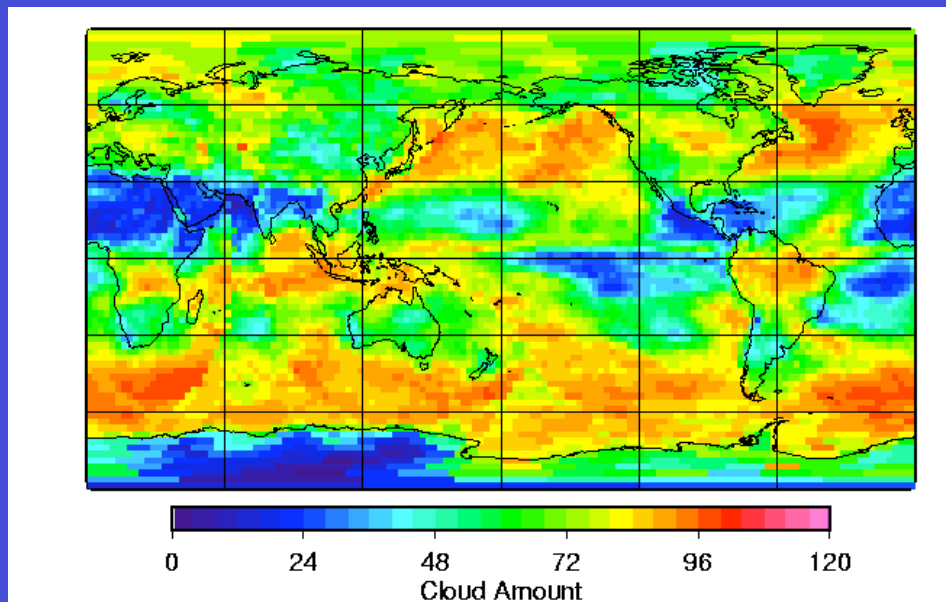
Principal Component Analysis

- Purpose
 - Test for potential GEO viewing geometry artifacts
 - Looking for GEO satellite patterns
- Method
 - Analyze TOA LW and SW Flux fields
 - (360 longitude)x(180 zones)x(36 months)
- Search for EOF GEO artifacts
 - Example of EOF GEO artifacts
 - Compare fluxes and de-seasonalized fluxes
 - Compare ISCCP and GEO fluxes
 - Compare nonGEO- GEO fluxes

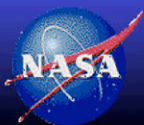


EOF Analysis Look for GEO viewing artifacts

ISCCP cloud amount, Feb 1994

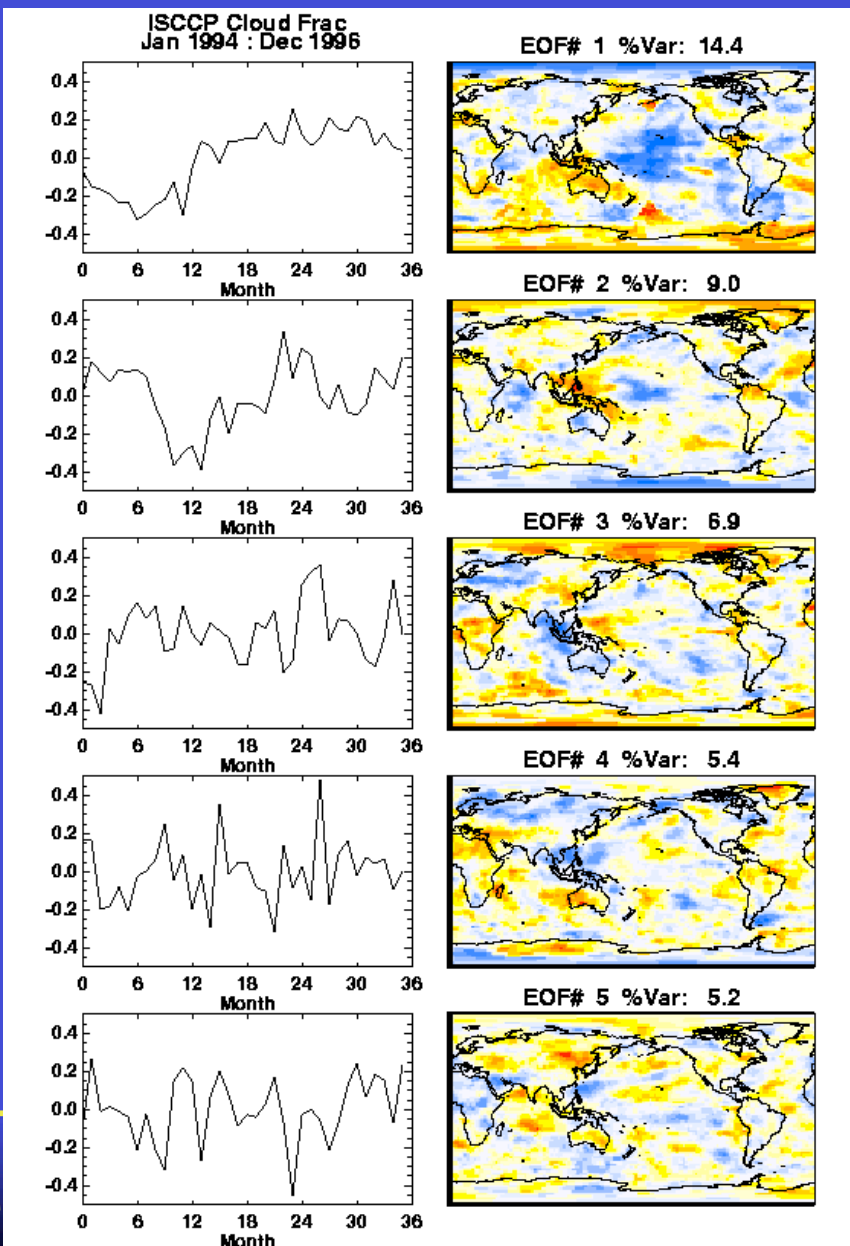


MET-7 GMS-5 GOES9 GOES8



NASA Langley Research Center

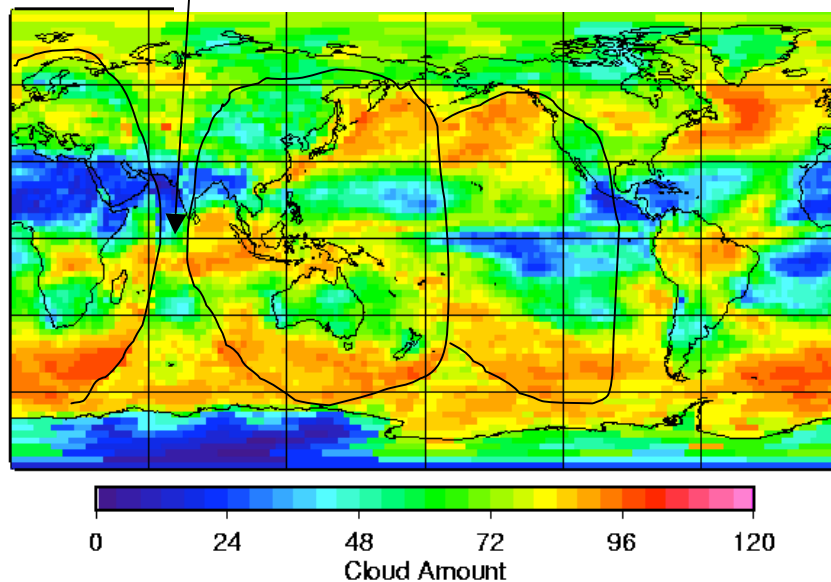
ISCCP cloud amount,
Jan 1994-Dec 1996, de-seasonalized



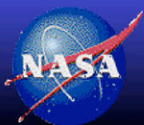
Look for GEO viewing artifacts

ISCCP cloud amount, Feb 1994

No GEO satellite in Indian Ocean

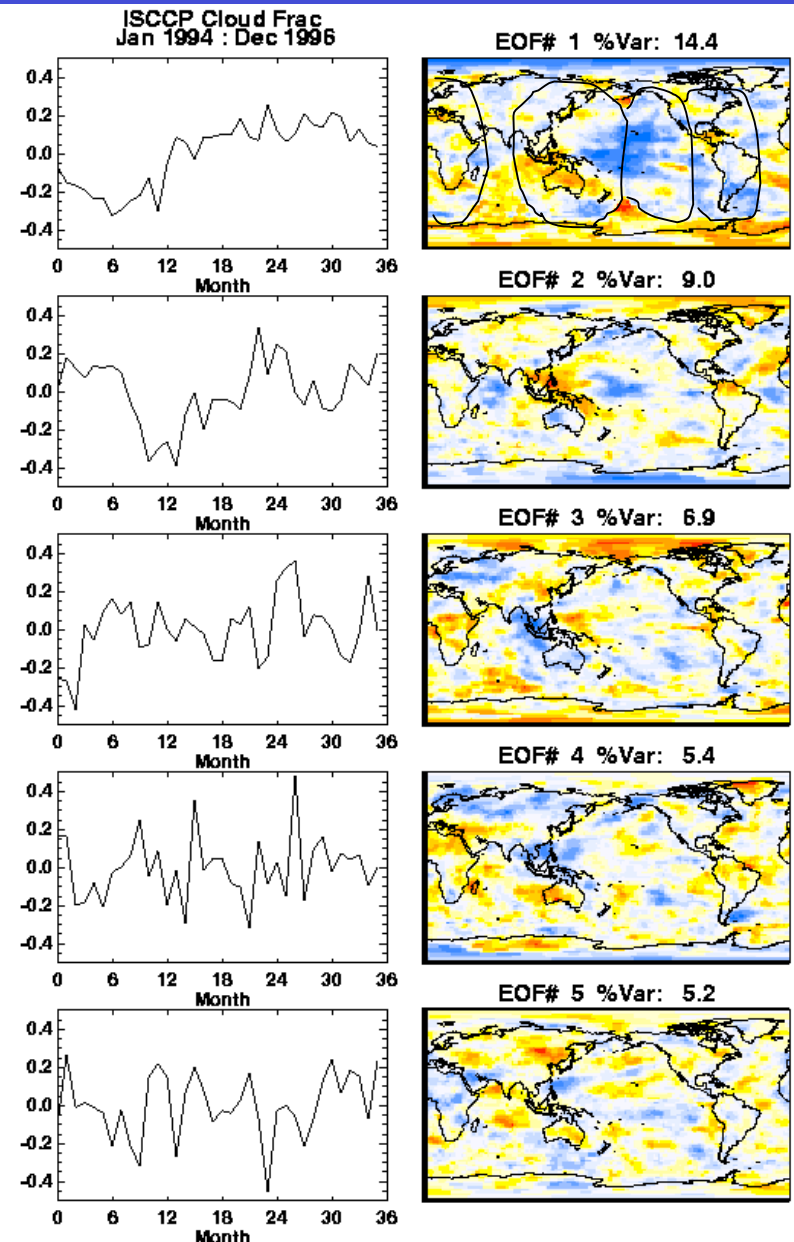


MET-7 GMS-5 GOES9 GOES8



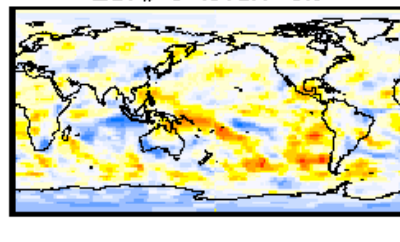
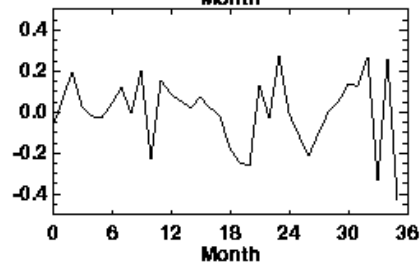
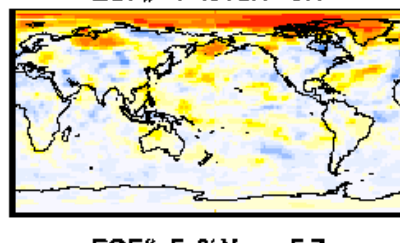
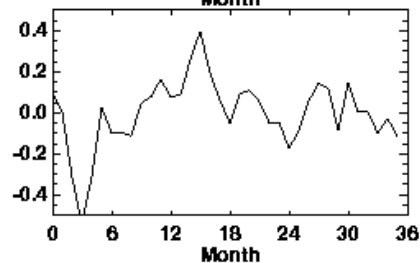
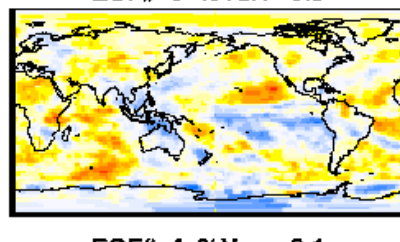
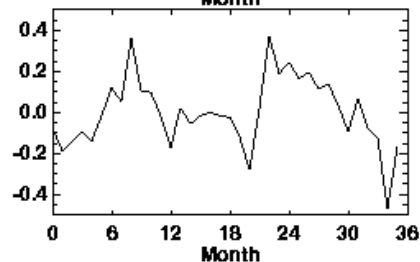
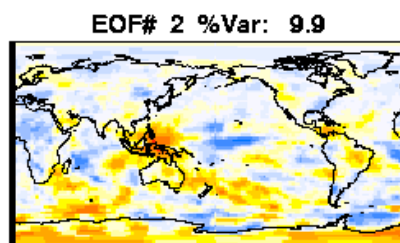
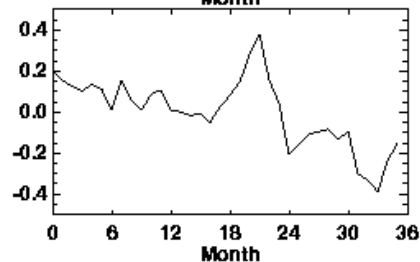
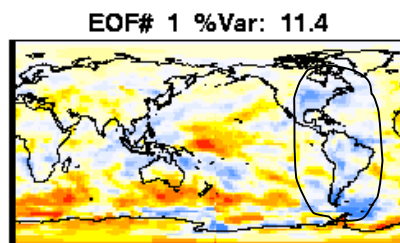
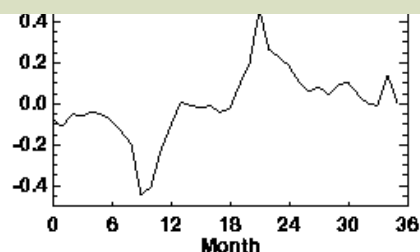
NASA Langley Research Center

ISCCP cloud amount, Jan 1994-Dec 1996, de-seasonalized



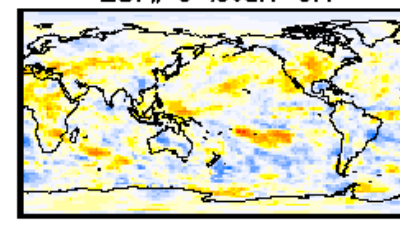
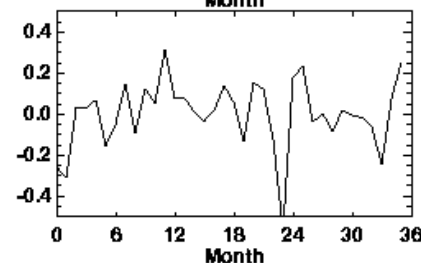
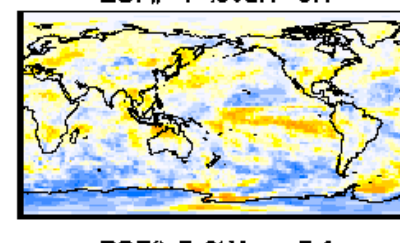
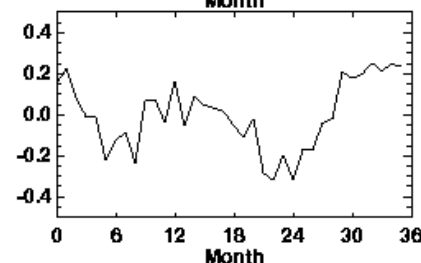
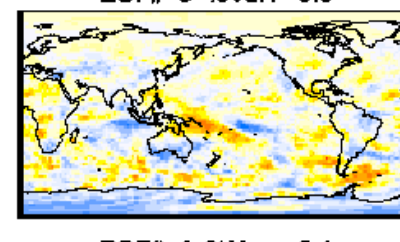
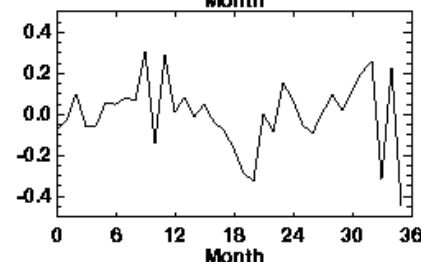
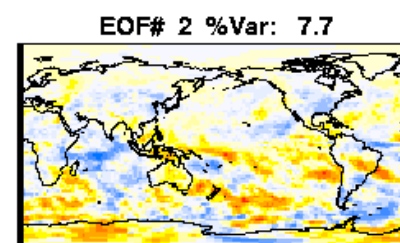
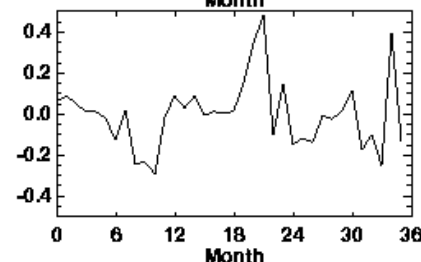
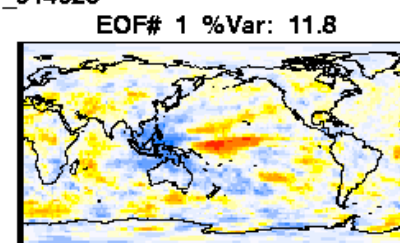
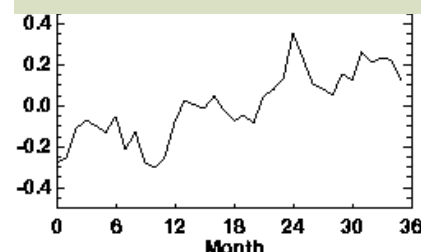
ISCCP SW EOF

de-seasonalized
Mar00-Feb03



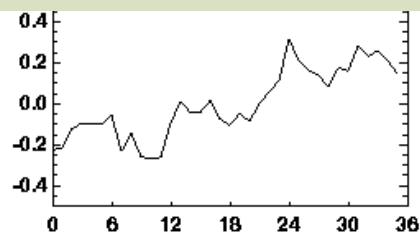
GEO SW EOF

de-seasonalized
Mar00-Feb03

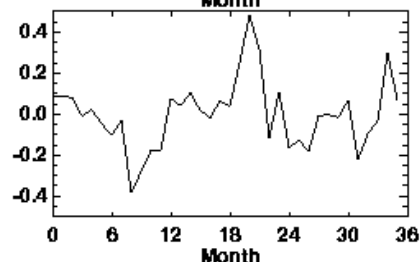
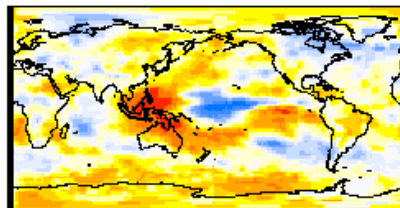


ISCCP LW EOF

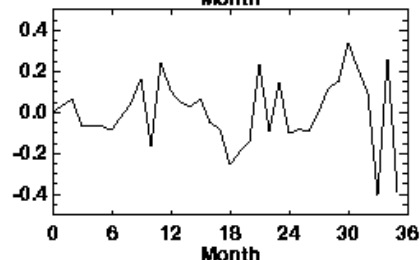
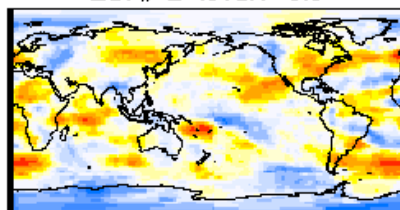
de-seasonalized
Mar00-Feb03



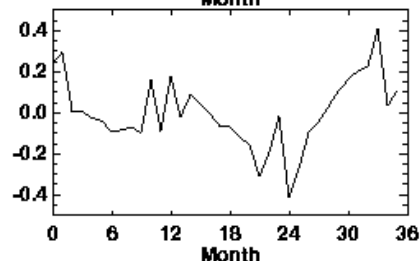
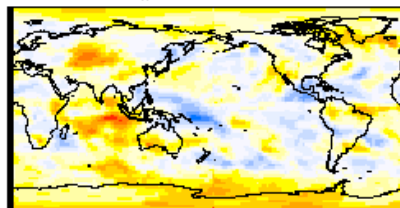
EOF# 1 %Var: 18.9



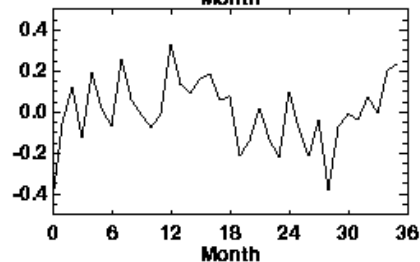
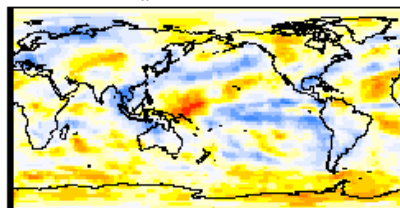
EOF# 2 %Var: 8.6



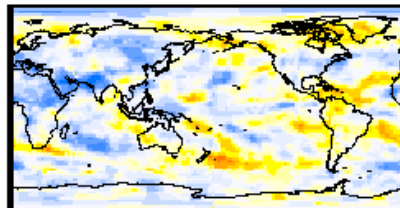
EOF# 3 %Var: 7.1



EOF# 4 %Var: 6.5

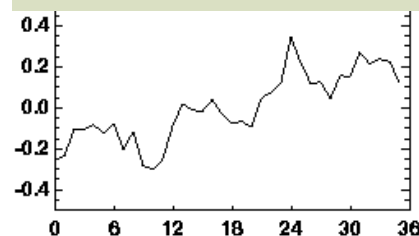


EOF# 5 %Var: 5.0

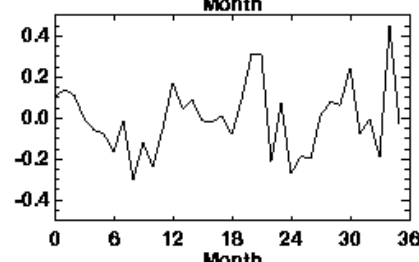
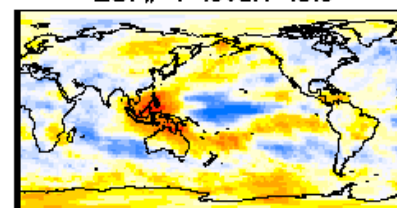


GEO LW EOF

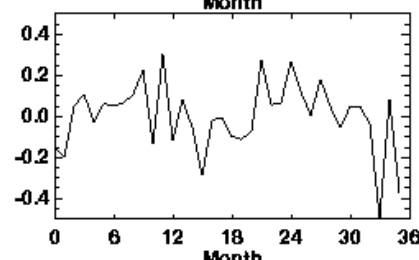
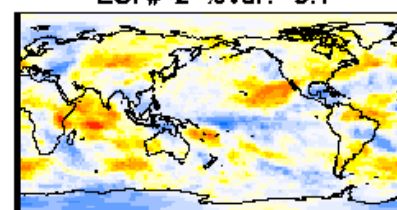
de-seasonalized
Mar00-Feb03



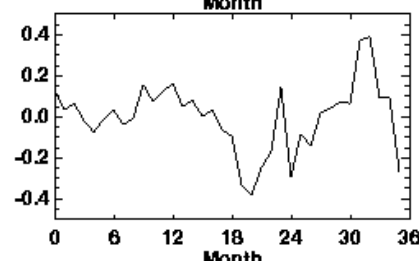
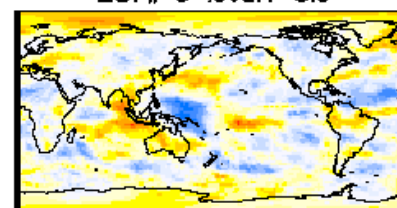
EOF# 1 %Var: 19.5



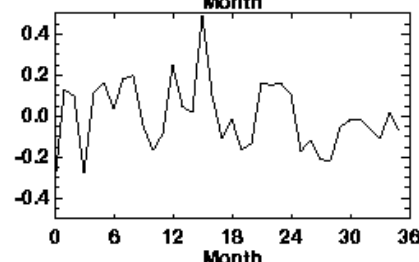
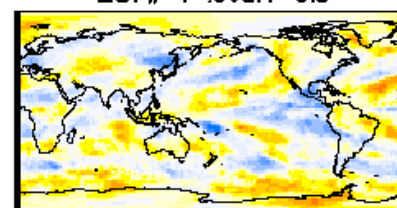
EOF# 2 %Var: 9.1



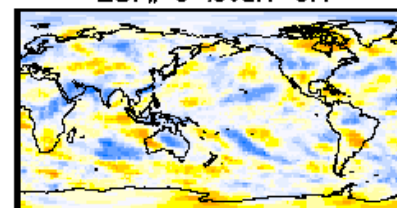
EOF# 3 %Var: 8.5



EOF# 4 %Var: 5.9



EOF# 5 %Var: 5.4

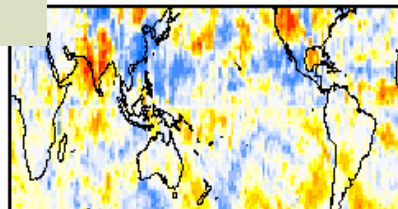
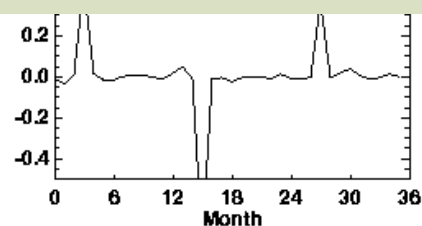


nonGEO-GEO SW EOF

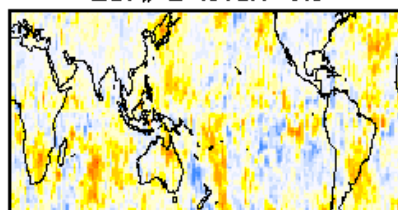
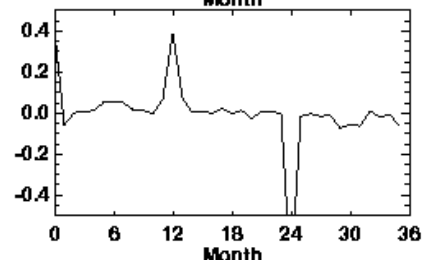
de-seasonalized
Mar00-Feb03

025

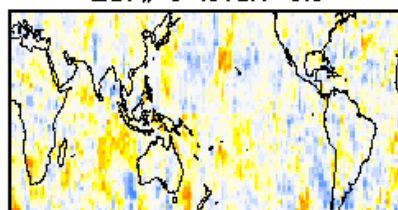
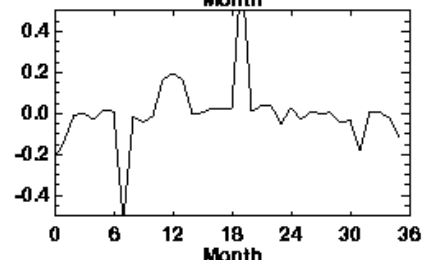
EOF# 1 %Var: 19.2



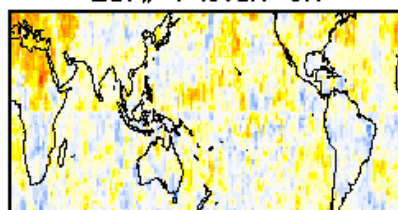
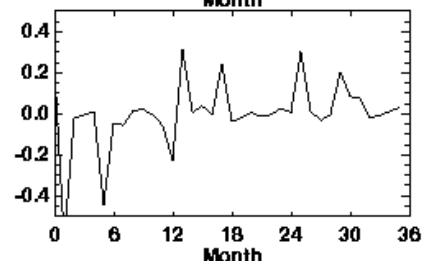
EOF# 2 %Var: 7.8



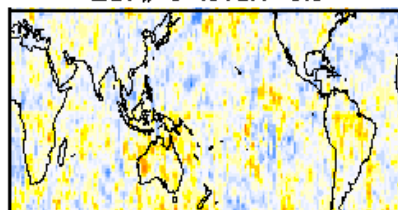
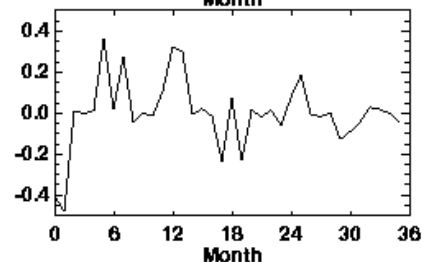
EOF# 3 %Var: 6.5



EOF# 4 %Var: 6.1



EOF# 5 %Var: 5.5

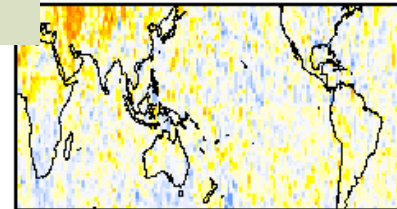


nonGEO-GEO LW EOF

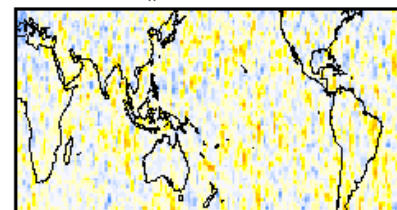
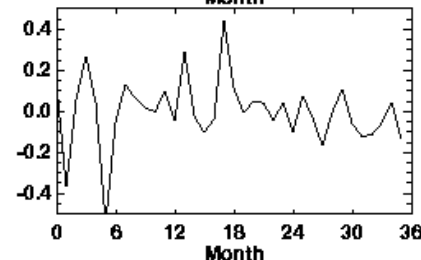
de-seasonalized
Mar00-Feb03

4025

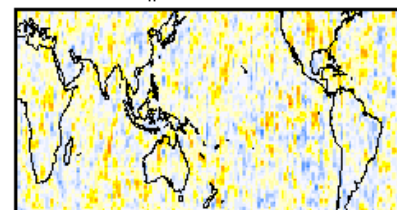
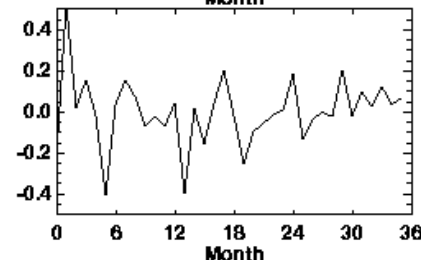
EOF# 1 %Var: 8.3



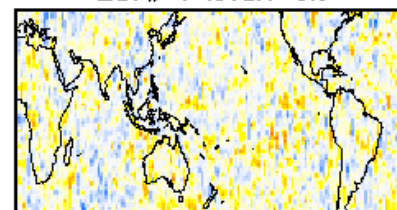
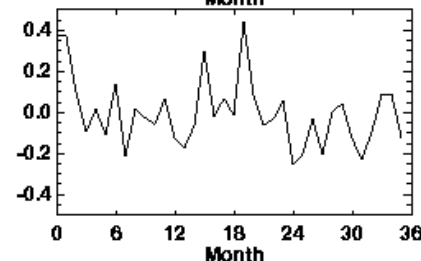
EOF# 2 %Var: 6.8



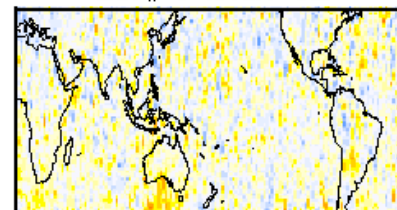
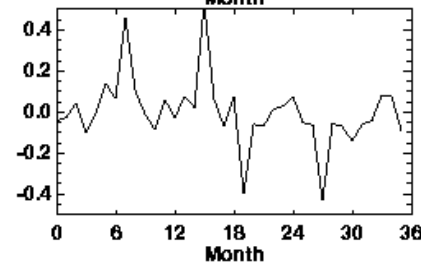
EOF# 3 %Var: 6.4



EOF# 4 %Var: 5.7

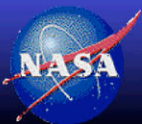


EOF# 5 %Var: 5.2



Summary of Principal Component Analysis

- No GEO artifacts observed in the SRBAVG-GEO fluxes
- ISCCP-FD and SRBAVG-GEO flux EOFs in general are similar, but have significant regional differences
- De-seasonalized flux EOFs tend to bring out the GEO viewing artifacts



Summary of SRBAVG Ed 2D consistency checks

	SW		LW	
(%)	Bias	RMS	Bias	RMS
Terra-Aqua (instantaneous) (day/night)	0.3 to 0.7	15.0	0.2 to 0.7 -0.5 to -0.3	4.6 4.5
Terra-Aqua (monthly)	1.0	4.2	-0.3	0.9
Surface (monthly)	3.2	11.3	0.0	3.1
SARB (instantaneous)	3.5	14.4	-0.6	5.1
GEO Calibration(monthly)	<0.1	<1.0	<0.1	<1.0
1 vs 3 hourly(monthly)	<0.1	2.5	<0.1	0.4
EOF	No GEO artifacts			
GEO directional	Consistent with CERES			

